DOCUMENT RESUME

ED 305 915 IR 013 774

TITLE	Improving the Use of Technology in Schools: What We Are Learning. Research Bulletin #1.
INSTITUTION	Center for the Study of Educational Technology, St. Paul, MN.
SPONS AGENCY	Minnesota Educational Computing Consortium, St. Paul.; Minnesota Univ., Minneapolis. Coll. of Education.
PUB DATE	Nov 88
NOTE	33p.
AVAILABLE FROM	Minnesota Educational Computing Consortium/University of Minnesota Center for the Study of Educational Technology, 3490 Lexington Avenue North, St. Paul, MN 55126 (two copies may be obtained free of charge, additional copies are $7.00 each).
PUB TYPE	Reports - Research/Technical (143)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Cognitive Processes; *Computer Assisted Instruction; *Computer Graphics; *Courseware; *Databases; Educational Technology; Elementary Secondary Education; Media Research; Skill Development
IDENTIFIERS	*Learner Control

ABSTRACT

This bulletin summarizes six studies on the integration of technology into education. Information provided for each study includes the background or the problem statement, study goals, methodology, conclusions, and recommendations. The first three studies focus on the impact of technology on education: "The Effect of Computer Use and Student Work Style on Database Analysis Activities in the Social Studies" (Don Rawitsch); "Pairing and Task Persistence Level in a Learner-Controlled Computer-Based Concept Lesson" (Carol Carrier, Michael Williams, Anju Relan, and Jason Earle); and "Using Computer Database Programs To Facilitate Higher-Order Thinking Skills" (Don Rawitsch). The other three studies focus on the design and use of technology-based products: "Open Desktop Environment: The Features and Benefits of a New Interface for Computer-Based Instruction" (Anju Relan); "Graphic Fidelity, Gender, and Performance in Computer-Based Simulations" (Gregory Sales and Michael Johnston); and "Pursuing 'Quality' in Instructional Software: A Progress Report" (Michael D. Williams). Each report provides bibliographic references, and citations for eight additional studies are listed. Manuscript specifications for submissions to this research bulletin are also provided. (EW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED305915

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

This document has been reproduced as received from the person or organization originating it.

Minor changes have been made to improve reproduction quality.

Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

Research Bulletin #1

November 1988

Improving the Use of Technology in Schools: What We Are Learning

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Vivian P. Johnson

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

IR013774

MECC/UNIVERSITY OF MINNESOTA
CENTER FOR THE STUDY OF EDUCATIONAL TECHNOLOGY

BEST COPY AVAILABLE

The purpose of the research bulletin, *Improving the Use of Technology in Schools: What We Are Learning*, is to provide educational decision makers with empirical data for making informed decisions relative to the integration of technology. It is designed to make research results available in a timely fashion and in an easy-to-read format. The research bulletin describes the results of studies conducted by the MECC/University of Minnesota Center for the Study of Educational Technology. It also describes other technology-related studies not conducted by the Center that might be of interest to decision makers.

TABLE OF CONTENTS

ADVISORY BOARD OF DIRECTORS i

FORWARD ii

IMPACT OF TECHNOLOGY ON EDUCATION

The Effect of Computer Use and Student Work Style on Database Analysis Activities in the Social Studies 1

Pairing and Task Persistence Level in a Learner-Controlled Computer-Based Concept Lesson 4

Using Computer Database Programs to Facilitate Higher-Order Thinking Skills 7

DESIGN AND USE OF TECHNOLOGY- BASED PRODUCTS

Open Desktop Environment: The Features and Benefits of a New Interface for Computer-Based Instruction 10

Graphic Fidelity, Gender, and Performance in Computer-Based Simulations 12

Pursuing "Quality" in Instructional Software: A Progress Report 16

ADDITIONAL RESOURCES ON RESEARCH IN EDUCATIONAL TECHNOLOGY 19

MANUSCRIPT SPECIFICATIONS 20

Advisory Board of Directors

Dr. William Gardner
Dean, College of Education
University of Minnesota

Dr. Dale LaFrenz
President and CEO
MECC

Dr. Carol Carrier
Associate Dean
College of Education
University of Minnesota
(Center Co-Coordinator)

Dr. Don Rawitsch
Administrative Vice-President
MECC
(Center Co-Coordinator)

Dr. Randall Johnson
Instructional Resources
Development Consultant
Anoka-Hennepin Independent
School District #11

MECC/UM Center Staff

Dr. Vivian Johnson
Planning Coordinator

Dr. Gregory Sales
Research Coordinator

Forward

The Center for the Study of Educational Technology is a unique partnership between MECC and the University of Minnesota College of Education. This partnership merges the practical experience and field-based success of MECC with the research expertise of the University. Founded in 1987, the Center was designed to improve the use of technology in schools. This goal is met by the Center's own research program by distributing information on research results of the Center and other institutions and by testing new models of field-based research.

Technology has been used in schools for many years but little empirically based research judging its effectiveness has accumulated. Dr. Peggy Roblyer of Florida A & M University bluntly states: "The overwhelming conclusion that you must come to is that there is not enough [technology-related] research to make good conclusions" ("World Leaders," 1988, p. 24). This lack of empirical evidence contributes to the growing apprehension about the value of continuing or expanding support for technology-related programs.

The Center's main focus is on conducting research to help build the empirical base related to technology use in the schools. By conducting its own research program and supporting the research of University faculty members, the Center is making contributions to this body of knowledge. However, the development of a research foundation alone will not help educators and the public decide on the appropriate use of technology.

To be useful, research results must be made available to decision-makers in a timely fashion and in a form that is easy to read. Center research results are published in scholarly journals, and the Center distributes two of its own publications: *The Research Synopsis* and *The Research Bulletin*. *The Research Synopsis* is a brief summary of current research results. *The Research Bulletin* is a detailed technical description of Center studies. Both publications are designed to present Center research and research efforts of other institutions in a format useful to educational practitioners.

Another Center focus is on the testing of new models for conducting field-based research. These models are an attempt to address the methodological shortcomings noted by researchers such as Dr. Henry Becker of Johns Hopkins University (Becker, 1987). Shortcomings include selecting student samples for the convenience of school class groupings instead of through a randomizing method, small sample sizes of typically fifty or fewer students, treatments of only a few weeks, and the lack of comparison groups to contrast to the technology-using students.

Finally, researchers and school administrators must work together to find creative solutions to the lack of school participation in technology-related research projects. The Center can facilitate discussions that address the following issues: (1) additional time and effort required by participating teachers, (2) scheduling the experimental

treatment to coincide with an appropriate period in the school's curriculum, and (3) limiting unexpected school scheduling changes that can disrupt research plans. Building a solid technology-related research base requires cooperative efforts to remove the traditional difficulties associated with field-based research.

The MECC/University of Minnesota Center encourages educators engaged in research on educational technology to share their findings and make known to the Center the kinds of information they have available for distribution.

References

Becker, H. (1987). *The impact of computer use on children's learning: What research has shown and what it has not.* Baltimore, MD: Center for Research on Elementary and Middle Schools, The Johns Hopkins University.

World leaders call for better research in educational technology. (1988). *Electronic Learning, 7* (8), 24-25+.

To Obtain Additional Copies of This Bulletin

Two copies of this bulletin may be obtained free of charge. Please write or phone the Center with your request. Additional copies may be obtained at a cost of $ 7.00 each.

IMPACT OF TECHNOLOGY ON EDUCATION

MECC/University of Minnesota Center
for the Study of Educational Technology
Project No. 88-1

The Effect of Computer Use and Student Work Style on Database Analysis Activities in the Social Studies

by
Don Rawitsch
MECC

Background/Problem Statement

This study (Rawitsch, 1987) was designed to generate research-based information describing the effects of using computer databases in junior high social studies learning activities. Social studies educators claim that the integration of database activities in the social studies curriculum helps students develop higher-level problem-solving and thinking skills (Parker, 1986) and learn how to manage information and solve problems (Hunter, 1983), and facilitates student probing of content, asking critical questions and testing their conclusions (Hannah, 1987). Unfortunately, the benefits to students from working with databases are based largely on experiential evidence. This has led to thoughtful challenges from members of the educational community, such as the following one by Schiffman (1986):

> Unlike the debate often triggered by discussions of CAI or Logo, almost everyone seems enthusiastic about teaching students to use "productivity tools" . . . . Articles regularly appear with suggestions for adopting productivity tools to school subject areas and with nary an accusation that . . . . "there is no research data to suggest they are of value." Is this a category of applications for which there are no philosophical or pedagogical reservations? (p.27)

Study Goals

Four hypotheses were explored in this study:

> Hypothesis I: Students will be able to solve problems requiring the comparative analysis of data more efficiently by using a computerized database as compared to non-computer methods.
>
> Hypothesis II: Students will prefer to use computerized methods of solving problems requiring comparative analysis of data.
>
> Hypothesis III: Students with a structured work style will use a computerized database more efficiently than students with an unstructured work style.

Hypothesis IV: Students will be able to apply computerized database methods learned in social studies-related activities to activities that more closely relate to future employment and/or home environments.

Methodology

The study involved 339 eighth-grade students from sixteen different classes in three suburban Minneapolis, Minnesota, school districts. The teachers and students were not drawn randomly from the general population and generalizations from the study are limited by several factors: (1) While the teachers did complete all the activities, additional training could have improved their effectiveness. (2) Student absence and forgetfulness led to a higher rate of missing data than expected. (3) The instruments used to collect data require further validation. (4) The design of the activity materials would benefit from further refinement.

Students in the study were involved in an eight-day treatment. During this period they completed a written questionnaire to determine their work styles, received instruction about databases, completed practice exercises using both a paper and pencil database and a computer database, completed specific exercises with both types of databases from which data were collected, and completed a questionnaire on their perceptions of the various database activities.

Conclusions

The findings of the study supported some of the hypotheses and were inconclusive in supporting others. Students solved a greater percentage of the problems correctly when they used the computer. However, they took more time to do so. If "efficiency" is defined as a *combination* of accuracy and speed, there was no significant difference between using the computer and not using it (Hypothesis I). Students liked using the computer better (Hypothesis II).

Students with a more "structured" work style were more efficient in using the computer than those with an "unstructured" work style (Hypothesis III). About half of the students performed as efficiently or more efficiently on the real-life computer exercise than on the academic computer exercise (Hypothesis IV). This indicated that there may be carry-over from one learning context to the next.

Recommendations

This study yields several implications for using database analysis activities in social studies. Of greatest importance is that problem solving with computer database use, like other aspects of computer-related instruction, cannot effectively be learned as a one-time activity or "unit" in the curriculum. Using only one time block of 1-2 weeks in

one subject area at one grade level to cover this skill does not necessarily justify using the computer in terms of student "efficiency." Further research will probably verify that students who can practice using databases periodically during their schooling will be significantly more efficient at finding information and solving problems with the computer than when using paper and pencil methods and will be able to solve problems of greater complexity.

The finding that students with differing work styles do not always perform with equal efficiency under the same instructional method deserves further examination. Taking all the students in a class into a computer laboratory and asking them to follow the same sequential set of instructions might ensure that only 50-75% of them will be successful in the activity. Teachers should be prepared to use alternative strategies matched to differing student work styles.

Regardless of performance efficiency, it appears that students prefer computer use over manual methods for analyzing data and prefer working with data in which they have a personal interest. This suggests using strategies that ease students into the more formal academic aspects of analyzing social science data.

The study adds new knowledge to a topic for which little research is present. In doing so, it suggests that further efforts are needed in determining the exact ways in which the computer can improve instruction and how the computer can be used more effectively with various types of students.

References

Hannah, L. (1987). Teaching database search strategies. *The Computing Teacher, 14* (9), 16-23.

Hunter, B. (1983). Social studies education in the information society. *Social Education, 47,* 321-324.

Parker, J. (1986). Tools for thought. *The Computing Teacher, 14* (2), 21-23.

Rawitsch, D. (1987). The effect of computer use and student work style on database analysis activities in the social studies. *Dissertation Abstracts International.* (UMI Dissertation Information Service Order No. 8805722.)

Schiffman, S. (1986). A strategy for helping students draw conclusions. *The Social Studies, 77* (2), 74-76.

MECC/University of Minnesota Center
for the Study of Educational Technology
Project No. 88-2

Pairing and Task Persistence Level in a Learner-Controlled Computer-Based Concept Lesson

by
Carol Carrier, Michael Williams, Anju Relan, and Jason Earle
College of Education, University of Minnesota

Background/Problem Statement

It has been reported that elementary schools now have more than 150,000 microcomputers in labs and classrooms (*Barbour,* 1987). Despite this impressive statistic, few schools have enough computers to allow students to work individually. Consequently, teachers frequently group children when conducting computer-based instruction (CBI).

Some research suggests that systematic grouping of students for educational activities is advantageous. For example, investigations related to cooperative learning (Johnson and Johnson, 1985) indicate that under conditions of a well-articulated goal structure, children working together have enhanced achievement over children working alone. One question investigated by this study is whether a casual approach to grouping helps or hinders student achievement in CBI.

The study also examined how pairing students affected the types of decisions made when they were given the chance to make choices during CBI. Previous research by some authors of this study (Carrier and Williams, in press; Carrier, Davidson, Higson, and Williams, 1984) demonstrated that: (1) in situations where students control the lesson they exhibited different levels of task persistence (willingness to explore options), and (2) the task persistence variable interacts with other instructional variables in interesting ways. Students have tendencies to select either high, medium, or low amounts of instruction when given control of a lesson.

This study extends the work of Carrier and Williams (in press) by examining the effects of pairing students under learner-controlled conditions. More specifically, the following questions are asked:

(1) Do students working in pairs achieve more than students working alone under learner-controlled conditions?

(2) Do students with high initial task persistence level learn differently than those with low initial task persistence?

(3) For paired students, what is the effect on achievement of matching or mismatching students with respect to task persistence level?

(4) Do students' confidence levels in their post-test performance predict their actual performance?

(5) What is the nature of student interaction between pairs of students matched as to task persistence versus mismatched?

Methodology

Ninety-four sixth-graders from a suburban elementary school volunteered to participate in the study.

A concept lesson in propaganda techniques was chosen for this study. The lesson was used in previous learner-controlled studies by Carrier and Williams and developed following the procedures recommended by Merrill and Tennyson (1977). The concepts presented are bandwagon, testimonial, transfer, and uniqueness.

The lesson begins with a concept definition. The concept definition is followed by a set of expository examples and non-examples matched with respect to feedback emphasizing the presence or lack of critical attributes. A lesson summary followed by a post-test requiring classification of new instances concludes the lesson. Students were allowed to choose the following instructional elaborations as they progressed through the lesson: a paraphrased concept definition, additional expository instances or practice instances, and analytical feedback.

Five administration days were required for data collection. On the first day, all students worked individually on the first concept under learner-controlled conditions. These student data disks were used to classify students according to high or low task persistence. Students were then randomized into one of the three treatment groups: individual, paired-matched, and paired-mismatched. These assignments lasted throughout the rest of the lesson until the post-tests. Paired students were gender-matched as well. All dialogue between pairs was taped.

Two identical post-tests of sixteen multiple-choice items were administered individually, one immediately following the lesson and one about a month later. Several items that assessed students' confidence about their performance on the instruction were included.

Conclusions

Preliminary data analysis suggested that pairing students did not lower achievement on the immediate or retention tests. There is some indication that pairing students with

dissimilar achievement levels results in the more dominant member of the pair influencing option selection behavior (e.g., a dominant high chooser will persuade a low chooser to select more options). Consistent with previous studies, individuals maintained their initial pattern of option selection throughout the lesson.

Recommendations

These results suggest that teachers can pair students during CBI without loss of achievement. However, if the lesson involves learner control, teachers should attend to dominant personalities within pairs because that may unduly influence what choices are made.

References

Barbour, A. (1987). Three new entries in education market form quite a crowd. *Electronic Learning, 6* (5), 11.

Carrier, C. A., and Williams, M. D. (In press). A test of one learner control strategy with students of differing levels of task persistence. *American Educational Research Journal.*

Carrier, C. A., Davidson, G .V., Higson, V., and Williams, M. D. (1984). Selection of options by field independent and dependent children in a computer-based concept lesson. *Journal of Computer-Based Instruction, 11* (2), 49-54.

Johnson, D. W., and Johnson, R. T. (1985). Computer-assisted cooperative learning. Unpublished manuscript, University of Minnesota, College of Education, Department of Psychology, Minneapolis.

Merrill, D., and Tennyson, R. (1977). *Teaching Concepts: An Instructional Design Guide.* Englewood Cliffs, NJ: Educational Technology Publications.

MECC/University of Minnesota Center
for the Study of Educational Technology
Project No. 88-3

Using Computer Database Programs to Facilitate Higher-Order Thinking Skills

by
Don Rawitsch
MECC
William M. Bart, and Jason F. Earle
College of Education, University of Minnesota

Background/Problem Statement

Parents, teachers, business leaders, and politicians have expressed the need to promote and improve students' higher-order thinking skills. Student use of computerized databases has been suggested as one means to achieve this goal (Parker, 1986). A small body of research has demonstrated that students who used databases increased their ability to classify and solve certain kinds of problems (White, 1985; Rawitsch, 1987; Underwood, 1985, as reported in Ehman and Glenn, 1987).

This study examined how students' use of computer databases affected two types of higher-order thinking skills: proportional reasoning and hypothetical-deductive reasoning. Proportional reasoning was assessed with a paper and pencil test. The test presented students with a series of balance beam problems. Students were asked to describe how the placement of weights at varying distances from the fulcrum affected the balance beam. Children "are aware that a balance is possible, but their attempts to attain it are always successive trial-and-error corrections" (p. 151, Wadsworth, 1984). It is not until adolescence and/or with instruction that children learn that an increase in weight on one side of the fulcrum can be compensated for by an increase in distance from the fulcrum on the other side (Piaget and Inhelder, 1969).

Hypothetical-deductive reasoning "involves deducing conclusions from premises which are hypothetical rather than from facts a student could actually verify" (Brainerd, 1978, as cited in Wadsworth, 1984). It was assessed by presenting students with written problems. An example would be presenting the student with a problem in the form *A is less than B, and B is less than C; is A less than C* ? The student demonstrating hypothetical-deductive reasoning can deduce that A is less than C (A < C) (Wadsworth, 1984).

The hypothetical-deductive assessment also required the ability to reason about hypotheses believed to be untrue (false premises) and still come to logical conclusions that can be inferred from the hypotheses. The student who can use hypothetical-deductive reasoning can also "submit to logical analysis the structure of the argument, independent of the truth or falseness of its content" (p. 139, Wadsworth, 1984).

Methodology

One hundred-and-fifty-eight seventh-grade students from a suburban junior high school participated in this study.

The study involved the use of two software packages: *The Oregon Trail* and *AppleWorks™*. Participating students used either *The Oregon Trail* or an *AppleWorks* database file. The students were studying the Civil War during the treatment period, so data files were designed to provide them with access to information about the northern and southern states (population, area, agricultural products, industrial products, etc.). Gains made by students using *The Oregon Trail* were compared to gains made by students using the Civil War database file.

The treatment spanned six days. A pre-test consisting of twenty-four proportional reasoning problems (Awang, 1984) and thirty hypothetical-deductive reasoning problems (Bart, 1972) was administered on Day 1. Following the pre-test, students were randomly assigned to one of three treatment groups: (1) *The Oregon Trail*, (2) database with debriefing before the post-test, and (3) database with debriefing after the post-test. Students in the treatment group working with *The Oregon Trail* used the simulation for three days and were given the post-test. In the database with debriefing before the post-test group, students were introduced to the features of *AppleWorks* (commands such as Find, Arrange, and Record) on Day 2. For the remainder of Day 2 and for the next two days, students used the database to answer questions about the states during the Civil War. On Day 5, students received a debriefing in which they were provided a verbal summary of the activities they had been involved with, and on Day 6, they took the post-test. The database with debriefing after the post-test group followed the same sequence as the other database group, except students received their debriefing after the post-test.

The post-test consisted of the same twenty-four proportional reasoning problems from the pre-test and thirty new hypothetical-deductive reasoning problems.

Conclusions

Preliminary data analysis indicated modest gains in the hypothesized direction. However, these gains were not large enough to support the conclusion that students' use of databases significantly improved their proportional reasoning or hypothetical-deductive reasoning skills. The largest gain occurred in the hypothetical-deductive reasoning of the group that used the database with debriefing after the post-test.

Recommendations

This preliminary study piloted an experimental design that might prove useful in determining the effects of students using databases. Follow-up studies should

incorporate at least two changes to the methodology. First, the treatment period should be longer and more comprehensive. Perhaps the activities should be spread out over more days to give the students time to absorb the new database skills. Second, observation of teachers and students during the study reinforced that teachers' behaviors and instructional strategies influence the effectiveness of computer-based activities. Thus, future studies should investigate teacher behaviors and instructional strategies in conjunction with the database activities. It appears that these factors work together to facilitate the development of higher-order thinking skills. The researchers believe that the instruments used to assess student reasoning skills have potential in this type of study and should be used in future projects.

References

Awang, M. (1984). Rule usage in solving formal operational problems among Malay and Ural American college students. (Doctoral dissertation, University of Minnesota, 1984).

Bart, W. M. (1972). Construction and validation of formal reasoning instruments. *Psychological Reports, 30,* 663-670.

Ehman, L., and Glenn, A. (1987). *Computer-based education in the social studies.* Bloomington, IN: ERIC Clearinghouse for Social Studies/Social Science Education.

Parker, J. (1986). Tools for thought. *The Computing Teacher, 14* (2), 21-23.

Piaget, J., and Inhelder, B. (1969). *The psychology of the child.* New York: Basic Books, Inc.

Rawitsch, D. (1987). The computerized database: Not a simple solution. *The Computing Teacher, 15* (4), 34-37.

Wadsworth, B. J. (1984). *Piaget's Theory of Cognitive and Affective Development.* Longman: New York.

White, C. S. (1985). The impact of structured activities with a computer-based file-management program on selected information-processing skills. *Dissertation Abstracts International, 47,* 513. (University Microfilms No. ADG86-07448.)

DESIGN AND USE
OF TECHNOLOGY-BASED PRODUCTS

MECC/University of Minnesota Center
for the Study of Educational Technology
Project No. 88-4

Open Desktop Environment: The Features and Benefits of a New Interface for Computer-Based Instruction

by
Anju Relan
College of Education, University of Minnesota

Background

Escalating school-related use of computers has led to the incorporation of accessible, easy-to-use interfaces in the design of computer-based instruction. This paper describes the features and potential benefits of using the "open desktop environment" in the design of computer-based educational software.

The "open desktop environment" was designed by researchers in the field of human factors to improve the effectiveness of the human-computer interface (Apple Computer, Inc., 1986). To date, the predominant use of the open desktop interface has been in tool software compatible with the Macintosh™ computer. However, software designers are starting to integrate this interface in software products for other microcomputers, such as Apple IIGS™, Amiga™ with programs operating on MS-DOS® systems, and IBM using the OS2 environment. However, integration of the open desktop interface in instructional applications has been relatively rare.

The desktop interface has evolved through several stages in the last fifteen years into its present form, accommodating within its framework and design concomitant hardware and software advancements (Smith, Irby, Kimball, and Verplank, 1982). During the same period, more sophisticated theoretical designs for computer-based instructional materials have been proposed, incorporating research on the cognitive functions of media attributes (Merrill, 1987; Park and Tennyson, 1980). This paper describes the features of this powerful interface in conjunction with instructional design principles to help establish guidelines for the effective use of this interface in the educational environment.

Methodolody

The evolution of the open desktop interface was traced through literature reviews spanning the last twenty years. Literature relating to the interface was requested from Xerox PARC, Palo Alto, California, where the idea of the desktop interface first originated. Extensive materials received from Xerox PARC provided the evolutionary background of the interface and information on the nature of human factors research that shaped its characteristic features (e. g., the desktop, the windows, the mouse, and pull-down menus). Literature pertaining to the theory and cognitive functions of media

attributes was also reviewed to provide a rationale for the multi-faceted use of the environment. Finally, examples of software incorporating the environment (e. g., *World Geograph* from MECC) were used to illustrate how features in the environment could be used for instructional purposes.

Results

The outcome of this effort was a set of guidelines describing procedures for effective use of the open desktop interface for instructional content. Thus, after instructional objectives have been formulated and the nature of content has been reviewed, the use of desktop environment would be most useful in meeting the following criteria.

(1) instruction that demands high learner control;

(2) dynamic interaction with content;

(3) hierarchically organized content;

(4) content with a varying difficulty level;

(5) interactive drill-and-practice or problem-solving activity;

(6) content supplemented with extensive writing and drawing; and

(7) multi-modal presentations.

Although the interface is highly flexible, it should not be considered a panacea for all instructional design issues related to computer-based instruction. Much is left to the ingenuity of the designer(s) to develop effective and creatively designed software.

References

Apple Computer, Inc. (1986). *The Roots of the Apple Desktop Interface.* In Human Interface Guidelines, 121-139.

Merrill, M. D. (1987). The new component design theory: Instructional design for courseware authoring. *Instructional Science, 16,* 19-34.

Park, O., and Tennyson, R. D. (1980). Adaptive design strategies for selection and presentation order of examples in coordinate concept acquisition. *Journal of Educational Psychology, 72,* 362-370.

Smith, L. D., Irby, C., Kimball, R., and Verplank, B. (1982). Designing the star user interface. *Byte, 7* (4), 242-282.

MECC/University of Minnesota Center
for the Study of Educational Technology
Project No. 88-5

Graphic Fidelity, Gender, and Performance in Computer-Based Simulations

by
Gregory Sales and Michael Johnston
College of Education, University of Minnesota

Background/Problem Statement

Designers of early educational software were often severely constrained by the technology of the times. Most schools were equipped with microcomputer systems that had small memories and poor-quality monochrome monitors and allowed for keyboard input only. These systems actually dictated software designs by limiting the use of color, sound, graphics, and animation.

Advances in technology have dramatically increased the capabilities of microcomputers targeted for the school market without increasing their cost. As a result, the constraints on educational software designers have been lessened. Increasingly, advanced uses of color, sound, graphics, and animation are now commonplace in educational software. But is there a point beyond which improvement of these features fails to positively affect the instruction being delivered? For example, can these feature enhancements provide too much stimuli? Will they work equally well for all students?

Sophisticated graphics and animations with increasingly high levels of fidelity are common in educational software, but their creation can be one of the most expensive and time-consuming components of the development process. Designers and producers invest in these graphics because they believe that (1) realistic graphics have a positive effect on learners' attitudes toward the instruction, and (2) attractive graphics help to sell software. While it would not make sense to argue for dull software or deny market factors, another important consideration is the instructional impact of the graphics.

Previous work by the authors indicated that learners' attitudes toward instructional software is not linked to the fidelity of graphics. In one computer-based study, learners in two groups were given software that was identical except for the fidelity of the graphics. After working through the program several times, the learners in each group were asked to evaluate it on the basis of (1) ease of use, (2) attractiveness, and (3) enjoyment. No significant differences were found between the responses from these groups on any of these items (Sales and Johnston, 1988).

Furthermore, there is no indication that high-fidelity illustrations are critical to learning. In fact, research using non-computerized delivery systems indicates that the level of graphic fidelity should not become too high (Dwyer, 1978). This research has shown that incorporating highly realistic illustrations in instruction can distract learners' attention from important points.

In addition to concern over the fidelity of the graphics, there is reason to question whether male and female students will learn equally from the same graphics. Art educators have documented that boys and girls in junior high school responded differently when given the opportunity to create computer art. Freedman (personal communication, April 1, 1987) noted that boys tend to create computer graphics with small, dynamic elements while girls tend to enjoy creating larger, static images.

This study examined how boys and girls responded to three distinct levels of graphic fidelity in computer-based simulations. It examines learners working with a simulation and investigates the relationship of performance and gender.

Methodology

The participants in this study were 120 eighth-grade students in a large suburban junior high school. The students were in five sections of a general science course and were encouraged to participate in the study, although participation was voluntary. A computer lab in the school was used for all data collection. The lab was equipped with thirty Apple *II*e computers. Each computer had a color monitor and a single disk drive.

The main data collection instrument used in this study was a computer-based simulation that required the user to develop strategies for successfully extinguishing a series of forest fires. Each simulation began with a screen display representing a forest in which three fires had begun to burn. (The locations of the initial fires, while changing for each run of the simulation, were identical for all users.) The user was informed that the fires were very hot and likely to spread to adjacent trees. Several techniques were available to the user to prevent the fires from spreading and eventually extinguishing them. These included dropping a fire-retardant chemical on the fire, using a bulldozer to clear a firebreak, setting backfires to consume the fuel supply in an area, and observing the fires as they burn. Each firefighting technique had associated advantages and disadvantages and was most effective under certain conditions. Similarly, each had an associated cost in dollars. The objective of the simulation was to save as many trees from the fire as possible while keeping expenses to a minimum.

Before the intervention, a list of participants was obtained and each was randomly assigned to one of the three treatment groups. Data was collected on two separate occasions. On the first day, participants received a verbal introduction to the simulation and were required to work through it two times. On the second day, they reported to the computer lab and were required to work through the simulation three

more times.

In this study three different types of screen display were compared in terms of learning efficiency and effectiveness. The following research questions were explored:

(1) Does the fidelity of the graphic display in a computer-based simulation affect the effectiveness of the instruction (as measured by the simulation dollars spent per turn)?

(2) Does the fidelity of the graphic display in a computer-based simulation affect the efficiency of the instruction (as measured by the decision time per turn)?

(3) Do boys and girls respond differently (in terms of efficiency and effectiveness) to graphic fidelity?

The different treatments were as follows:

Numeric screen display—Information was represented by color-coded numbers. Each number and color represented a different object or condition. For example, fire was represented by an orange number 7 and as it burned, the number decreased until it reached 1, at which point it disappeared (the value displayed represents the intensity of the fire).

Realistic Icon screen display—Information was represented by colored icons designed to look like the objects they represented. For example, a hot fire was represented by a large, orange flame which, as it burned, got smaller until it finally disappeared.

Block Icon display—Information was represented by color-coded, block-shaped icons of different sizes and colors. The color and/or size of each block represented a different object or condition. For example, a hot fire was represented by a large, orange block which, as it burned, got smaller until it finally disappeared.

Conclusions

Six of the 120 participants failed to complete the study due to absences. Data from the remaining 114 participants was used for all of the analyses.

A two-factor repeated ANOVA measurement of the mean decision time per turn was conducted to determine differences in efficiency by "game" and by treatment. The results indicate that for each treatment group the initial run of the simulation took the longest, but that the Block Icon group took significantly longer to make decisions than the Realistic Icon group ($F = 92.63$, $p < 0.001$). After the first use of the simulation graphics, fidelity did not make a significant difference in efficiency.

To remove the effect of the initial introduction to the simulation, only the data from the final three simulations was used to determine the effectiveness of the instruction. A two-factor repeated ANOVA measurement was also conducted to determine the relative effectiveness of the treatments (as measured by dollars spent per turn). No significant difference in effectiveness by treatment was found.

Two one-way ANOVA's were conducted to determine the effects of gender on decision time per turn and dollars spent per turn. Both analyses found that boys performed significantly better ($F = 15.22$, $p < 0.001$; and $F = 5.57$, $p < 0.02$, respectively).

Recommendations

During the initial use of a computer-based simulation, the fidelity of computer graphics does seem to make a difference in learner performance as measured by the time spent making decisions. This difference, however, does not carry over into subsequent uses. This would suggest that designers of instructional software should consider the likely used patterns for a simulation when determining the level of detail to be incorporated into graphic displays. Simulations that are likely to be used only once or infrequently may require higher fidelity. It may not be as important to invest the same level of effort into simulations that will receive frequent use.

The difference in performance based on gender was consistent across all treatments. This may suggest that girls found all of the graphics, regardless of treatment, unappealing or uninformative. Perhaps the girls would have preferred larger, more colorful representations. Researchers should begin to probe more deeply into the graphic needs and preferences of boys and girls to encourage more active engagement of both groups in the use of educational software.

References

Dwyer, F. M. (1978). *Strategies for improving visual learning.* State College, PA: Learning Services.

Sales, G. C., and Johnston, M. D. (1988). The effect of graphics on performance and attitude in a computer-based simulation. Paper presented at the meeting of the Association for Educational Communications and Technology, New Orleans.

MECC/University of Minnesota Center
for the Study of Educational Technology
Project No. 88-6

Pursuing "Quality" in Instructional Software: A Progress Report

by
Micheal D. Williams
University of San Diego

Background/Problem Statement

This report describes the status of an on-going study investigating the question, "What is software quality?" The study attempts to discern whether different players in the field of computer-based instruction have different definitions of, or values toward, "quality" instructional software.

Teachers using educational software in their classrooms are faced with a bewildering assortment of products. The volume of available software and limited budgets for purchasing software reinforce the need for prudent purchasing decisions. As professionals and as good consumers, teachers wish to use the best-quality software. Unfortunately, no precise definition of quality software exists. It is also not known whether the different users of educational software agree on the characteristics that make one piece of instructional software "better" than another one.

The issues of quality in any endeavor is complex and, indeed, arguments verge on the philosophical (see for example, Robert Pirsig's book, *Zen and the Art of Motorcycle Maintenance).* The same can certainly be said for the field of instructional software. Arriving at an agreed-upon yardstick for assessing quality (if, indeed, such a goal is feasible) requires intensive investigations spanning many domains and addressing the concerns of many audiences.

Previous work by the author has documented that: (1) publishers are expanding their markets for instructional software, (2) guidelines for the design of computer-based instruction are proliferating, and (3) numerous reports discuss the scarcity of "good" software. For example, Bialo and Erickson's (1985) analysis of 163 elementary and secondary-level courseware reviews, concluded that, "... much of the courseware currently being developed is poorly designed and does not take advantage of the potential to the microcomputer."

Of the many possible kinds of questions that could be asked about software quality, those relating to the *definition* of quality would seem to be necessary to ask first. That is, until we can get a handle on what it means to have "good" software, it would seem premature to advance to the questions of how to achieve quality.

Methodology

The study to date has completed a pilot test of the semi-structured interview instrument. The actual study participants will be volunteers who can serve as articulate representatives for a number of specialties, across several domains related to instructional software. These include:

(1) producers and sellers of software (including professionals in CBI *design* and *marketing*);

(2) consumers of software (including *school teachers* and *media/technology coordinators*); and

(3) judges of software (including *evaluators and magazine reviewers* and *academics*).

A list of potential subjects will be compiled, based on an individual's recognition by his or her peers. Eighteen people from this list (six from each group) will be invited to serve as a blue-ribbon panel for the study. Alternates will be asked, should a first-choice candidate decline to participate.

Eighteen identified panel members will be sent a brief description of the study and an invitation to participate. Each subject will participate in a taped phone interview. During the interview, questions will be asked from the first two sets, as listed above. The interviewer will encourage respondents to elaborate, qualify, and develop their answers. This study does not follow a fully structured interview format, as open-ended questions are asked and any kinds of answers are accepted. The last set of questions will be sent to each participant for rating after the conclusion of the phone interview.

Responses will be transcribed from the tapes for analysis. Researchers will code, classify, and sort types and patterns of responses to determine whether there are substantial differences between groups.

A pilot interview form was created by the author after surveying published reports describing factors deemed to constitute good-quality software. The interview questions are designed to assess opinions regarding what software quality is. Several formats for different items were used to increase the likelihood of comprehensive responses. A semi-structured interview format allows for follow-up questions by the interviewer.

This instrument was pilot-tested by conducting in-person interviews with one person from each of the preceding professional categories (except evaluator/reviewer). Also solicited were opinions of the comprehensiveness, clarity, redundancy, and ease of response of the items. Information gathered during the pilot phase was used to add, delete, and clarify some of the items.

The finalized instrument contains the following types of queries:

(1) *Reactions*—Subjects are to react to twelve different statements about the nature of "quality" of instructional software. Statements will be read to each participant, such as "The number of awards given to a piece of instructional software is a good index as to its quality." The participants are to react to each statement as to the degree they agree or disagree. Some of these statements are intentionally designed to be somewhat controversial to elicit a strong opinion.

(2) *Opinions*—Here, the subjects are asked to provide general opinions about the nature and definitions of "quality" instructional software. For example, participants will be asked, "How do you judge a particular piece of software? What do you look for?" This section is more open-ended in nature than the preceding section.

(3) *Ratings*—Subjects are to rate the importance of items presented in a recent list of "quality" software factors in the report *Power On!* published by the U.S. Congress Office of Technology Assessment.

Do the participants generally agree or disagree with the items on the list, and how might they rank order their importance?

Conclusions/Recommendations

The participants in this study were not randomly selected and their opinions may not be reflective of the populations they represent. A larger-scale, follow-up study will be conducted to validate the responses of the current study. This will take the form of a mail survey sent to a large number of professionals active in the educational software field and will objectively validate opinions collected from the statements drawn in the current study.

At this time it is unknown whether the forces driving the development and consumption of computer-based software are operating under different definitions of quality. Until we better understand how these value systems may differ, it is difficult to improve the state of software use in our schools. This study is a first-stage attempt to describe the yardsticks used by different audiences to assess quality educational software and make explicit differences that may exist.

References

Bialo, E .R., and Erickson, L. B. (1985). Microcomputer courseware: Characteristics and design trends. *AEDS Journal, 3*, 227-236.

Pirsig, R. (1979). *Zen and the Art of Motorcycle Maintenance*. New York: Morrow.

ADDITIONAL RESOURCES ON RESEARCH IN EDUCATIONAL TECHNOLOGY

These resources are selected because of the comprehensiveness of their coverage of research trends and their timeliness of publication.

Becker, Henry. (1988). *The impact of computer use on children's learning: What research has shown and what it has not.* Baltimore, MD: Center for Research on Elementary and Middle Schools, The Johns Hopkins University.

Capper, Joanne, and Copple, Carol. (1986). Computers in education: Research review and instructional implications. *The Research Into Practice Digest, 1* (3).

Hunter, Beverly. (1988). Research and evaluation trends in the uses of computer-based tools for learning and teaching. *Proceedings: NECC '88*, 82-94. Eugene, OR: International Council on Computers for Education.

Kurland, D. Midian, and Kurland, Laura. (1987). Computer applications in education: A historical overview. *Annual Review of Computer Science, 2*, 317-358.

Krendl, Kathy, and Lieberman, Debra. (1988). Computers and learning: A review of recent research. *Journal of Educational Computing Research, 4* (4).

Martinez, Michael, and Mead, Nancy. (1988). *Computer competence: The First National Assessment.* Princeton, NJ: Educational Testing Service.

Office of Technology Assessment, U.S. Congress. (1988). *Power on! New tools for teaching and learning.* Washington, DC: U.S. Government Printing Office.

Roblyer, M. D. (1985). *Measuring the impact of computers in instruction: A non-technical review of research for educators.* Washington, DC: Association of Educational Data Systems.

MANUSCRIPT SPECIFICATIONS

The MECC/University of Minnesota Center is interested in reporting the research results of educational practitioners and researchers from other institutions. Two copies of each manuscript should be submitted. Manuscripts should be typed double-spaced on one side of an 8-1/2 by 11-in. sheet of paper, with uniform margins. The author's name, professional title and affiliation, address, and telephone number should appear on a separate sheet of paper. Manuscripts should conform to the following guidelines.

Description

The manuscript should be viewed as an expanded abstract. It should include a background/problem statement, study goals, methodology, conclusions, and recommendations. A description of each section follows. The abstracts are published in the Center's research bulletin, *Improving the Use of Technology in Schools: What We Are Learning*. Currently, the bulletin is published once a year and is mailed to individuals who have requested specific information about Center activities. The bulletin has a diverse readership, including university faculty, staff development personnel, computer coordinators, and teachers. While the research bulletin is more technical than popular computing magazines, authors should write for a diverse audience with different levels of expertise with educational research. A good rule of thumb when writing manuscripts is to view the research bulletin as an intermediate step between the non-technical article and an article appearing in a scholarly journal.

Background/Problem Statement

This section describes and defines the question or problem and provides background information. This includes the importance or significance of the project, identification of audiences that may find project results useful, working definitions, and limitations of the study. When possible, validate the problem definition with supporting citations.

Study Goals

This section briefly describes study goals or hypotheses.

Methodology

This section contains descriptions of the sample, research design, and measurements used. The population from which the sample was drawn and the method of selecting the sample should be detailed in the sample description. A short description of the educational environment in which the project took place is highly desirable. Details of the research design should include identification of the type of research design and review of the steps taken to collect data, including any that may have influenced the

results.

Conclusions

This section briefly describes research results.

Recommendations

The emphases in this section should be on the identification and interpretation of the major findings. When possible, discuss why the results may have occurred, fit them into findings of previous research, suggest field applications, and make theoretical interpretations (Borg and Gall,1983). The Center is especially interested in how research results affect classroom use of technology.

Please follow the American Psychological Association (APA) format in setting up the reference sections of the paper.

References

Borg, W., and Gall, M. (1983). *Educational Research: An Introduction (4th ed.)*. New York: Longman.

3490 Lexington Avenue North
St. Paul, MN 55126
(612) 481-3677